CONVERTER STEEL FOUNDRY PRACTICE

BY

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Converter Steel Foundry Practice

A THESIS

PRESENTED BY

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PART I

FOUNDRY STEEL PRACTICE IN GENERAL

STEEL PROCESSES

[illegible]

The word steel, nowadays, covers a multitude of mixtures, which are very different from each other in their chemical as well as physical qualities. The ingredient that exerts most of the influence on these variations, is carbon.

Pig iron and cast iron contain about 3.5 percent of carbon; wrought iron only a trace of it. In between these two extremes we find steel. Therefore, the manufacture of steel refers principally to getting right proportion of carbon.

There are two general methods of doing this, one by adding carbon to wrought iron as in the crucible process, and the other by burning out carbon from pig iron. There are numerous ways of doing these things, and a few of the important ones will be described.

CRUCIBLE PROCESS

In the crucible process, puddled iron, or open hearth scrap, low in carbon, is melted in small, closed pots with sufficient charcole or washed metal (Iron containing about three percent of carbon) to produce steel of the desired carbon content.

The pots each contain about 100 to 500 lbs. of metal, and are heated by coal, coke, gas, or oil. The process is one of pure melting and as no impurities are eliminated from the steel, pure steel is produced only by the use of pure metals.

Oxidation of the metal by the gases of the furnace is, however, largely avoided, since the steel is protected from the flame by the pot and its cover.

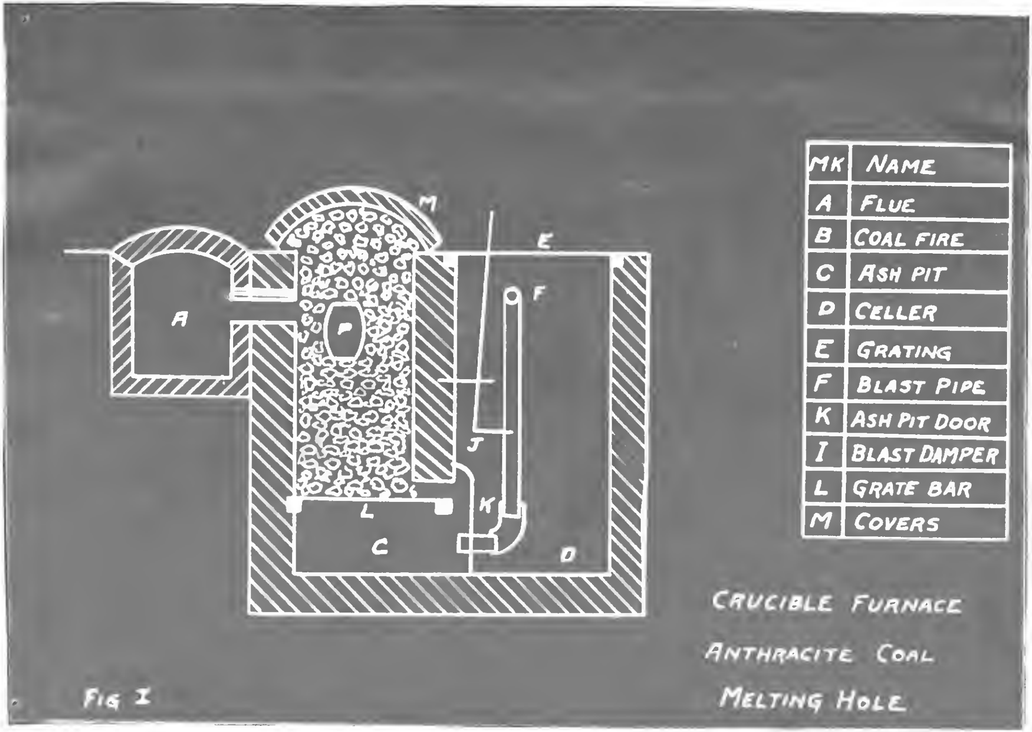

MK NAME
A FLUE
B COAL FIRE
C ASH PIT
D CELLER
E GRATING
F BLAST PIPE
K ASH PIT DOOR
I BLAST DAMPER
L GRATE BAR
M COVERS
A
B
C
D
E
F
J
K
L
M
CRUCIBLE FURNACE
ANTHRACITE COAL
MELTING HOLE

FIG I

BESSEMER PROCESS

In the Bessemer Process the molten pig iron is put into a pear shaped vessel, called the converter, the bottom of which is double, the inside plate being perforated with numerous holes, called tuyeres, to admit air to be forced in under pressure. The molten iron (from ten to fifteen tons) is poured into converter while latter is lying on its side, then vessel is turned to a vertical position after the blast has been turned on. There is sufficient air pressure to prevent the metal from entering the tuyeres. The air stream passes up through the molten metal, (piercing it like so many needles) burning out the carbon, silicon, etc., accompanied by a brilliant display of sparks and a flame shooting out of the mouth of the converter.

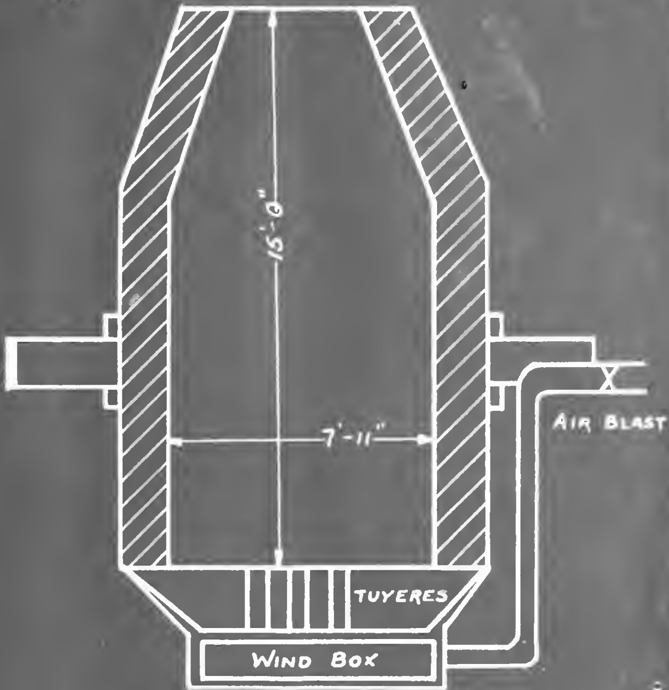
The fifteen tons of molten pig iron contains nearly three quarters of a ton carbon, and since this carbon is all burned out in less than ten minutes, this rapid rate of combustion increases the heat of the metal very much: it does not cool it off as one would first suppose. The flame, therefore, at first red, becomes brighter and brighter, until it can scarcely be looked at with the naked eye.

A blow usually lasts about nine or ten minutes, when sudden dropping of flame shows all impurities of iron are burned out. The metal then left in converter is practically wrought

iron: the converter is again pulled down to horizontal positon, the blast shut off and a certain amount of ferro silicon, ferromanganese, is added to make metal suitable for the purpose desired.

The liquid steel is then poured out into so-called "ingot molds", and the resulting "ingots," while still hot, are rolled into blooms, billets, or rails without any additional reheating except short sojourn in so-called "soaking pots."

In some steel works, where the molten pig iron is taken from large ladle cars direct from blast furnace to converter, it is possible to produce rails without adding any heat to that contained in molten pig iron, so that red hot rail just finished contains some of the heat given it by the coke in blast furnace.



15 TON CONVERTER
SECTION

FIG 2

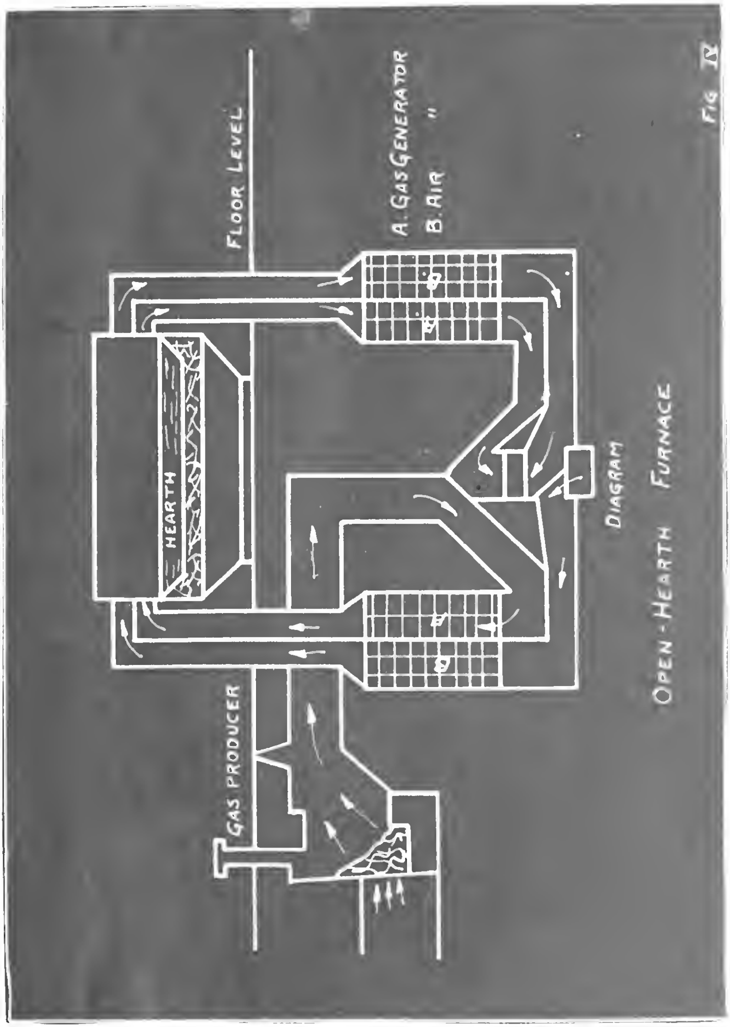
THE OPEN-HEARTH PROCESS

The Open Hearth Process, some times called "The Siemens Martin Process," is similar to the puddling process, but on a much larger scale. The furnaces generally have capacity of from five to fifty tons of molten metal some times as high as two hundred tons. They are heated by oil, gas from bituminous coal, and natural gas. The gas and air needed for its combustion are heated to a high temperature before entering the combustion chamber by passing through so-called regenerative chambers. Owing to this pre-heating of the gas and air, a very high temperature can be maintained in the furnace, so as to keep iron liquid even after it has parted with its carbon.

The stirring up of the molten metal is not done by hooks as in puddling process, but by adding a certain proportion of the ore, iron scale, or other oxides, the chemical reaction which keeps molten pig in state of agitation.

While in the Bessemer Process only pig iron is used, in open hearth furnace it is practicable to use scrap of wrought iron or steel, as the high temperature in the furnace will readily melt it. When the pig iron or scrap contains too much phosphorus, burnt lime is added to the charge; the resulting slag will absorb the phosphorus, thus taking it out of the metal.

This dephosphorization by means of burnt lime is called basic process, in contradistinction to acid process, where no lime is used, but where care must be taken that the metal charged is low in phosphorus. In this country, the basic process is at present used only in connection with open hearth furnaces, while in Europe it is also used in many Bessemer plants, producing so-called "basic Bessemer steel."


FLOOR LEVEL
A. GAS GENERATOR
B. AIR "
HEARTH
GAS PRODUCER
DIAGRAM
OPEN-HEARTH FURNACE
FIG IV

ELECTRICAL PROCESS

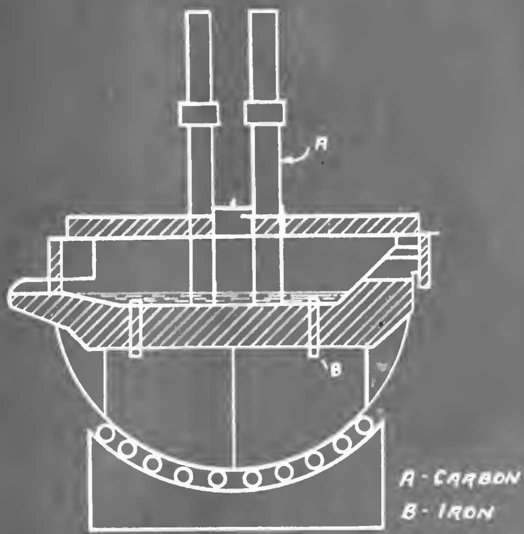
The usefulness of the electric furnace in steel foundry work is due wholly to the fact that it allows the steel maker to carry elimination of phosphorus, sulphur, oxides, and gases, to a point not possible to obtain in any other steel making process.

There are no limitations to the kinds of steel that can be made in this furnace. Here additions of alloys of any kind, in any amount, can be made with good results and with very little loss of alloy. Another point in favor of the electric furnace is ability to melt steel scrap containing costly alloy, without oxidation and loss of alloys that occurs in working up the scrap in the Bessemer, or open hearth processes, or the great gain in carbon so difficult to avoid in crucible melting.

Electric furnaces are divided into two general classes determined by the manner of generating the heat and applying it to both. The arc furnace and the resistance furnace are the two general classes, and arc furnaces are divided into pure arc and arc resistance furnaces.

The electric furnace has a great field before it, that is, when the initial cost is lowered, the cost of operation is kept going down, and the demand for such a high grade of steel is such that product can be sold at a profit.

This process for high quality steel and small castings which are demanded intermittently, is hard to improve upon and has a field which is bound to increase.



GIROD ELECTRIC FURNACE

SIDE BLOW

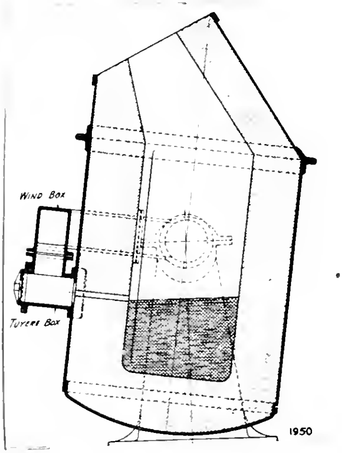
CONVERTER PRACTICE

The converter process is similar to Bessemer process only air passes over metal instead of through it. The size of charge is very much smaller, but everything else is practically the same.

The flexibility of the side-blow converter is a strong point in its favor, and as cost of installation is low where grey iron foundry has been in operation, many are used in grey iron foundries where small steel castings are needed intermittently.

The Tropeanas Company were the originators of the side-blow process.

The cross section of Whiting converter shows shape of shell, and as this is of great importance in running vessel efficiently, would say it should be followed as closely as possible.



For light, intermittent, jobbing shop jobs, the converter has no equal and here lies its greatest field.

STEEL MOULDING PRACTICE

Good steel moulding practice depends upon many things. In the first place, the ramming of steel castings is not so important but any one with strong arm can ram them. The mould has to be properly vented and it is impossible to overemphasize the importance of thorough venting. Again, the skin drying of green sand moulds by torch just before closing, is of great importance in reducing the amount of steam and gas to be taken care of in pouring.

The proper venting, setting, and making of cores is essential to good steel moulding, just as it is in grey iron work. The sand used is a little stronger than that used in grey iron work, and more silica sand can be used without any detrimental effect upon castings. Bottom gate pouring is considered good practice in all steel work, especially gears and heavy work.

The shrinkage in steel work is greater than in grey iron work, and one must be sure that one quarter inch to a foot has been allowed for same. However, this can be said of steel floor, that any one who has been successful on grey iron floor can handle work on steel floor without much chance for loss.

STEEL MELTING

One thing must be remembered in converter steel blowing and that is, that nearly all of impurities of the iron are practically burned out and one must be sure to add after blow, the amount of the elements desired in the casting. The metal that is poured into vessel is as low as possible in phosphorus and sulphur. If more heat is desired from oxidation of silicon, some silicon is added by addition of ferro silicon.

The best of coke should be used in the cupola in order to keep the sulphur as low as possible. The phosphorus in initial pig and scrap should be very low also. In short, the kind of metal from cupola to converter must contain enough silicon to insure hot heat, medium manganese, low phosphorus, and low suplhur. The amount of silicon, manganese, and carbon can be regulated by additions to ladle or converter after blow, of ferro silicon, ferro manganese, and carbon in same state.

The amount of these various elements depends entirely upon sections of castings desired and the purpose for which they are to be used.

SCRAP LOSES

The thing probably of greatest interest in any foundry is the scrap pile. To reduce same by finding out causes and preventing same from occuring again, is the practice of every up-to-date foundry man.

Scrap loses can be due to a number of things: The patterns may be made wrong in the first place, or core may not be set right nor fastened securely, allowing hot metal to push it to one side when entering.

Any of the above would cause casting to be thrown in scrap pile. The core and also the mold may not have been properly vented, causing blow holes and gas pockets and sending more castings to pile. Poorly designed patterns cause internal strains which cause shrinkage, breaks, and more scrap steel.

Another addition may be caused by what is known as cold shut, where metal coming from two directions will not fuse properly but lap over each other. Cold metal probably causes such things. The drop caused by some of sand not remaining in proper position in mold, but running around and resting where it does not belong, causes scrap. This may be due to the sand being too wet, extra hard flash usage, or by

knocks in clamping up flask. Improper metal some times is the cause for scrap, and such cases should be traced at once to proper cause.

Too much phosphorus in heavy castings might be responsible for segregation, causing sponginess. Phosphorus too low in detail work might be cause for metal not taking proper outline.

The scrap pile must be studied, the trouble ascertained and then remedied in order to increase production and cut down foundry costs.

WELDING - ANNEALING

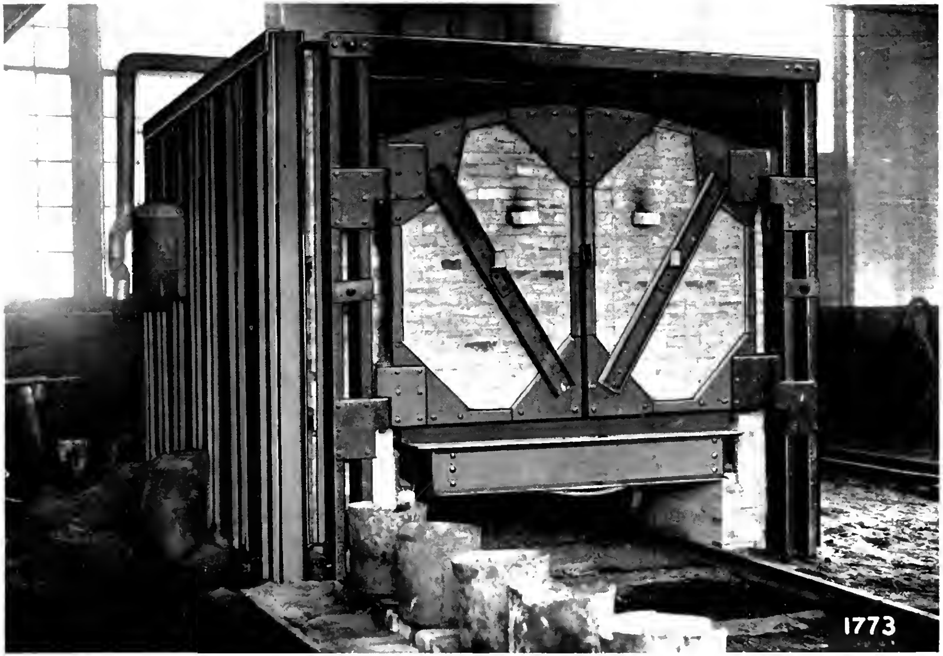
[illegible]

The present use of welding is cutting down scrap loses very nicely, and with recent additions to welding apparatus, the scrap losses are now down to a minimum. All small holes, especially in steel castings, can be filled up on welding floor. Steel can be machined but cast iron is lost if weld has to be machined, due to harm done tool.

Since electrical and acetylene welding has come into vogue,more and more steel castings have been saved until now a casting has to be in pretty bad condition or be of very great importance before it is scrapped. This has helped speed up production and saved many, many castings.

The annealing is done to all castings where there is a liability of internal strains due to different section. In some plants they make it a policy to anneal all steel castings. Annealing is not merely bringing casting up to a certain temperature in annealing oven and then holding it at that temperature for some time before allowing to cool slowly, but is a knowledge of what this or that casting needs and whether this or that casting needs quick cooling before being finally heated and allowed to cool slowly.

Annealing does in no way change the chemical composition of the steel, but it has a physical effect upon same. The molecules are rearranged in casting, thus relieving strain.



OIL BURNING ANNEALING OVEN IN CONVERTER STEEL FOUNDRY OF DELAWARE & HUDSON CO., WATERVLIET, NEW YORK
CAPACITY: 5 TO 10 TONS

FIELD OF THE SIDE BLOW CONVERTER

[illegible]

[illegible]

[illegible]

[illegible]

The greatest field for the side blow converter is found among the producers and users of small steel castings, especially those places where grey iron is being produced. The increase of 145,000 tons per year of converter steel from 1903 to 1917 indicates the development of this line.

The equipment installed in any grey iron foundry can be used for converter, thus bringing initial cost to a minimum. The operation of a converter needs no high-priced man and any intelligent person can become a good converter operator with enough training.

The need of corporations, engaged in jobbing work, for quick production, opens a new field as they can not allow the lack of small steel castings to hold up production. Everyone knows that small jobs let out do not receive the attention of larger jobs, that these smaller jobs are looked after when everything else has been done. One small casting probably would hold up some $40,000 to $50,000 job and mean a loss of thousands of dollars. Therefore, small manufacturers and jobbing shops have felt the need of side blow converter and are ordering same.

All in all, this field for converters is increasing every day and soon no grey iron foundry will be complete without one, or some other way of working steel.

CONVERTER PRACTICE

IN GENERAL

The converter, to look upon, is a very simple machine, and so are all of its operations. However, to properly supervise the operation, a great deal of study is required, also practice, and the ability to mix irons. When one has decided upon the metal desired for steel castings in question, the work has just started. The proper amount of scrap, proper percentages of various pig piles, proper additions of ferro manganese and silicon, are figured and charges made up from these figures. One must be careful to allow for cupola and converter gains and losses in these various elements.

Cupola is started and charges thrown in after bed is burned through. The blast is turned on and melting starts from about five to eight minutes later. In about twenty minutes metal is tapped and when ladle is full it is brought to converter. Proper additions needed for heat are made and after setting converter so that metal in vessel just touches tuyeres, the air is turned on and the blow starts.

The blow has three distinct periods; First, we have silicon period where most of the heat in the blow is obtained. This lasts from four to six minutes.

Next is manganese period, known as boil, or rather boil occurs during this period, which lasts from five to eight

minutes. The last period is the carbon period where all carbon is burned out. The flame is now very bright as compared with smoky, brownish flame of first period, and boil of second period.

At the end of carbon period, the finish flame appears, which seems to want to climb to roof. When flame is at its highest point one has to watch for drop, which shows that practically all carbon is burned out and that vessel must be turned down and air shut off or there will be mothing left but slag.

The vessel is tilted forward while proper additions are made either to ladle or vessel in order to give metal with desired results. Metal is then poured in ladle and is ready for steel floor.

POURING STEEL INTO MOLDS
AMERICAN CLAY MACHINERY COMPANY, BUCYRUS, OHIO

PART II

WHITING STEEL PRACTICE

The steel practice followed by the Whiting Foundry Equipment Company will be dealt with in detail. This will start from receiving outside material to the chemical analysis of finished product, as furnished the machine shop.

RECEIVING AND TESTING OF MATERIALS

Wish to state in starting that all material for foundry practice is bought under specifications and that is the only profitable way to run a foundry.

Pig iron is delivered in carload lots under specifications which have to be lived up to by contractor. Upon arrival of carload of pig, chemist is notified and he at once selects about eight pigs to be used as samples, taken from various points in the car.

These pigs are drilled after rough surface has been ground off and there is no possibility of any dirt getting into sample. A magnet is used in picking up borings so as to keep them as clean as possible. The sample is now taken to laboratory and tested for silicon, sulphur, phosphorus and manganese. The results obtained show whether or not specifications have been met and whether car can be unloaded.

This is policy used in testing all of our outside material. If contents of car is all right, car is unloaded and piled neatly together in pig yard. The number of the car is painted on three or four pigs, which, because of their position, will be in the pile until the end.

The iron received that does not come up to specifications, is held in car and we either get a reduction in price or ship the car back, getting what we ordered.

Weighing Up Charges in Foundry Yard, Showing Whiting Transfer Scale Car,
Advance-Rumley Co., La Porte, Ind.

STEEL PIG.

		SIL.	MG.	PHOS.	SULPHUR.
205694	25 TON	2.21	.46	.047	.036
		2.25	.40	.031	.031
37999	39 "	2.90	.54	.036	.014
		2.70	.40	.032	.015
21813	29 "	2.07	.54	.035	.018
		2.37	.50	.032	.013
14399	25 "	2.24	.45	.035	.021
		2.29	.40	.032	.017

THE TOP ANALYSIS IS OURS AND BOTTOM SPECIFICATIONS UNDER WHICH PIG WAS BOUGHT.

NOTICE HOW CLOSELY SPECIFICATIONS ARE MET.

TABLE #1.

Coke is received in carload lots and is also sampled before unloaded. The coke sample is obtained from twenty or more pieces of coke from various points in the car. These pieces are all mixed together so one is sure to get a fair sample of material received. The coke is taken to the chemical laboratory and tested for carbon, ash, volatile matter, and sulphur.

A coke order usually states carbon to be at least 88% and sulphur under .8%. This analysis gives fairly good coke and the kind we always order and make sure that we receive.

Scrap iron is received and unless scrap is uniform very little can be gotten from analysis of one piece or another. One has to strike a general average and the results can be taken and used for cupola mixtures.

All other material, such as ferro silicon, ferro manganese, and any other material where chemical make-up is important, is tested in laboratory.

The sand, oil, wood, firebrick, bonds, sea-coal, and all other materials needed for foundry, are inspected to see that they are as ordered.

ANALYSIS OF COKE.

CAR Nº	BRAND	ORDER #	MOIS.	VOL.	F.C.	ASH	SUL.
625062	INDIANAP.	L-8017	.06	3.34	88.69	7.93	.74
175264.	LOW SUL. COKE.	L-9989	.56	1.53	89.00	8.91	.70

THE ABOVE COKE BOUGHT UNDER THE FOLLOWING SPECIFICATIONS.
CARBON TO BE AT LEAST .88
SUL. TO BE NOT MORE THAN .08

TABLE #2

FORMATION OF CHARGE

BY CHEMICAL ANAYLSIS

Iron of the following chemical analysis is desired for converter practice.

Silicon - just enough to give required heat in blow, about 1.40%.

Manganese - medium high, that is about .5 to .6%.

Sulphur - as low as possible, not forgetting that some is added in melting pig iron.

Phosphorus must be kept low and low phosphorus pig must be ordered as in that way low phosphorus in finished product is assured.

List below gives grades and analysis of material in steel yard:

Car	Brand	Tons	Price	Sil.	Mang.	Phos.	Sul.
161653	Low Phos.	39.0	41.90	2.44	.09	.036	.016
239471	Lebanon	47.99	40.90	3.52	.13	.042	.013
288382	Robesonia	40.0	46.70	2.33	.10	.029	.006
Spring Scrap Plate				.25	.50	.050	.050

The charge sheet filled out by manipulation of pig for various elements, is shown on the following page. We assumed weights to use of each class and then show what these figure up.

WHITING FOUNDRY EQUIPMENT CO.

CUPALO MIXTURE SHEET

Mixture for STEEL MIX. S-14

STEEL Casting Date 2-10-20

MATERIAL		LBS. PER CHARGE	SILICON		MANGANESE		PHOSPHORUS		SULPHUR	
KIND	CAR NO.		%	LBS.	%	LBS.	%	LBS.	%	LBS
Pig Iron	14323	150	2.50	3.75	40	.60	.035	.052	.023	.034
" "	118237	150	2.50	3.75	51	.77	.038	.057	.020	.030
" "	289509	100	1.00	2.88	46	.46	.036	.036	.038	.038
Spring Scrap		450	.25	1.135	40	1.60	.050	.225	.050	.225
Plate Scrap		150	.25	.375	40	.80	.050	.075	.050	.075
Spiegel		6			4800	2.88				
TOTAL LBS.		1006		11.88		7.11		.445		.402
Gross % Silicon Mang. Phosphorus and Sulphur			% 1.18		%	.71	%		%	
Changes in Melting		SUBTRACT → %	11	SUBTRACT → %		.14	.044 NO CHANGE!	ADD 6% OF SULPHER IN COKE →	.044 .036	
Net % Silicon, Mang. Phosphorus and Sulphur			1.18		.57		.044		.080	
Mixture Analysis			% SILICON		% MANG.		% PHOS.		% SULPH.	
Date This Mixture is Used			.98		.50		.042		.08	
" "										
" "										
" "										
" "										
" "										

Mixture Figured By

Approved SAMPLE

It is noted that nine pounds of ferro manganese is used in order to bring up manganese. This is good practice because results desired are obtained with pig and scrap on hand. However, if it were possible to buy low phosphorus and sulphur pig which had enough manganese in it so that no additions were necessary, this would be much better.

On this table it is noticed that actual analysis of cupola metal before entering converter is lower than figured upon. This probably is due to taking sample from bed charge where some of manganese and silicon has been oxidized.

The main thing is to remember cupola losses and additions in figuring charges, and that one or two points either way in any elements, is not detrimental.

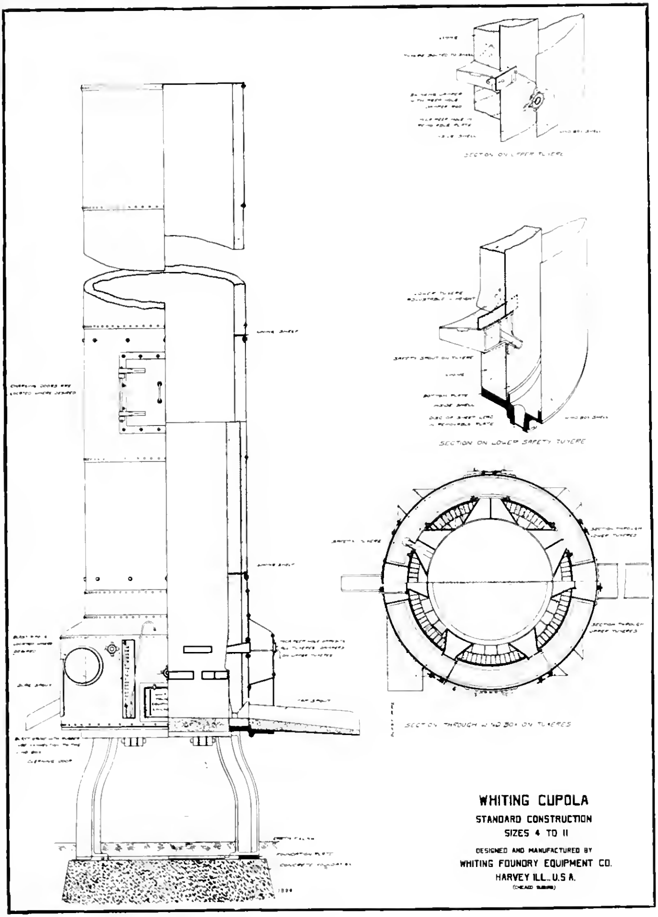
CUPOLA PRACTICE

The necessary cupola practice, demanded in order to obtain metal in molten state for converter practice, is practically the same as for good grey iron practice. The main idea is to obtain proper results for desired mixtures by correct mixing of metals, the use of good coke, and the proper amount of air. The cupola used in melting operation appears in illustration on page 53.

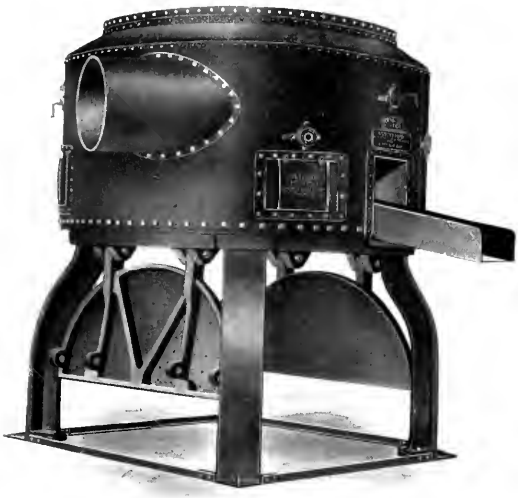
The cupola is prepared for the run by chipping out all slag in melting zone which remained from last heat, and also clearing out tuyeres so that they are in good shape and that nothing prevents air from passing through them.

If any part of the cupola has been burned out, it is patched up with daubbing, made from two parts loam and one part fire clay. The bottom is closed and layer of sand is placed on bottom, tramped down with feet so as to be firm and to be about four inches at back, three inches at tapping spout. The sand must be dry, and should be clean, containing nothing which might act as lead from molten metal to cupola bottom. In other words, should act as a perfect insulator between hot metal and cupola bottom.

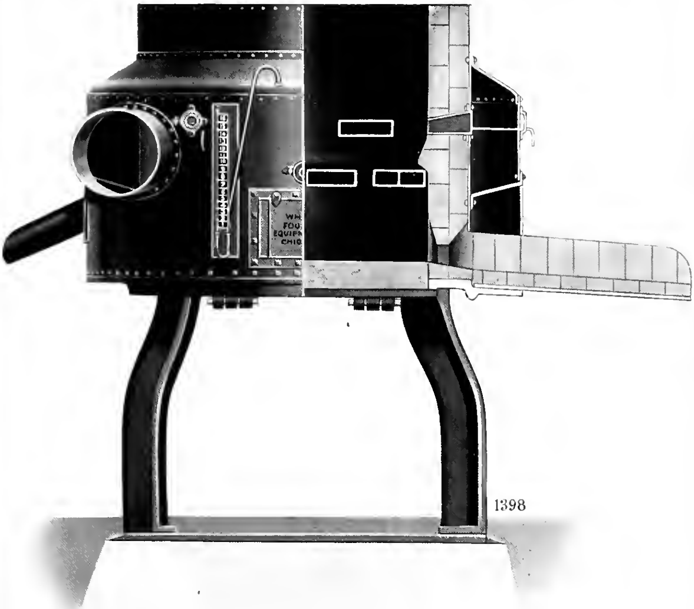
The tap hole and the slag hole must be clean and the spouts in good shape.



SECTION ON UPPER TUYERE
SECTION ON LOWER SAFETY TUYERE
SECTION THROUGH WIND BOX ON TUYERES
WHITING CUPOLA
STANDARD CONSTRUCTION
SIZES 4 TO 11
DESIGNED AND MANUFACTURED BY
WHITING FOUNDRY EQUIPMENT CO.
HARVEY ILL. U.S.A.



THE WHITING PATENT CUPOLA
Body Section (D)



THE WHITING CUPOLA

Elevation of Section (D)

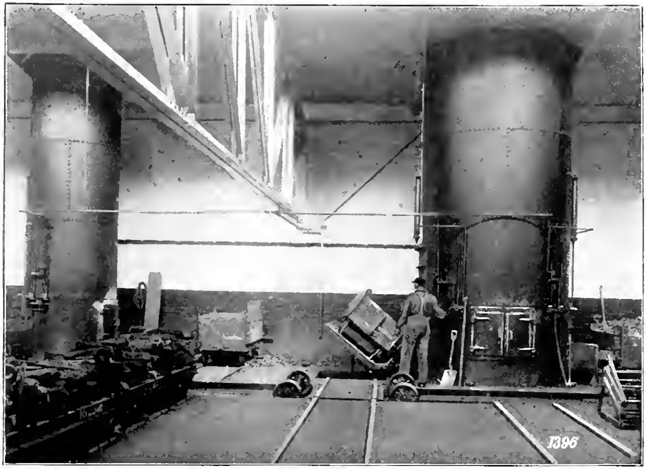
THIS CUT INDICATES CLEARLY THE INTERNAL CONSTRUCTION OF THE BODY

The charges are weighed in the yard, made up as far as material goes, as per instructions of superintendent, and then brought up to charging floor by means of crane. The coke is also brought up after a large container has been filled in yard. Stone, if required for heat, is also hoisted up by means of crane.

If the above has all been done then cupola is ready to operate. Shavings and wood are thrown in, being sure that none of wood sticks in sand bottom. This is followed by most of the bed charge of coke, lighted and allowed to burn clear through before coke is added, filling up required amount of bed charge and therefore being sure of level bed.

The charges which are now thrown in contain steel scrap and steel pig, the steel scrap consisting of plate and springs. In placing such a charge in cupola one would naturally place pig near edge of cupola with scrap in center, but not so in this practice as the steel scrap takes as much heat, if not more, to melt it as does the steel pig.

Between each charge of metal of the above make-up is placed 125 lbs. of coke which at first appears high, as

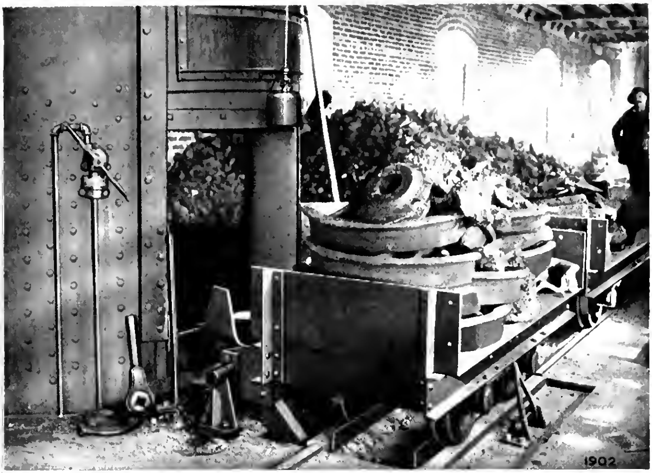


View of Charging Floor in Foundry of General Electric Co., Erie, Pa.
Whiting Equipment Used Here

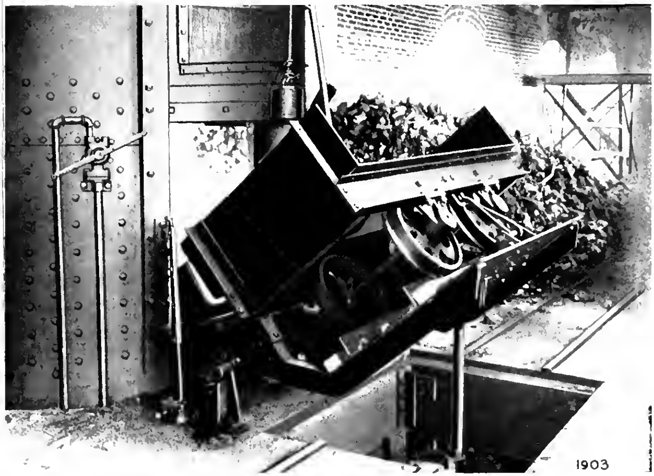
coke ratio in good cupola practice should never exceed ten to one, but we have to consider that we are now melting steel which requires higher heat than grey iron.

The charges are now placed in cupola all the way up to charging floor and allowed to remain in this way until about twenty minutes before metal is desired, when the blast is turned on. The only draw back to this is that initial blow will contain a high sulphur, due to long contact with coke in bed charge.

The first metal appears in from five to eight minutes, and a ladle of hot iron is ready in about twenty to twenty-five minutes. This ladle is transferred to nose of converter and poured into same by use of crane. The ladle is brought back ready to take next tap.



1902 SIDE DUMP CHARGING MACHINE READY TO DUMP



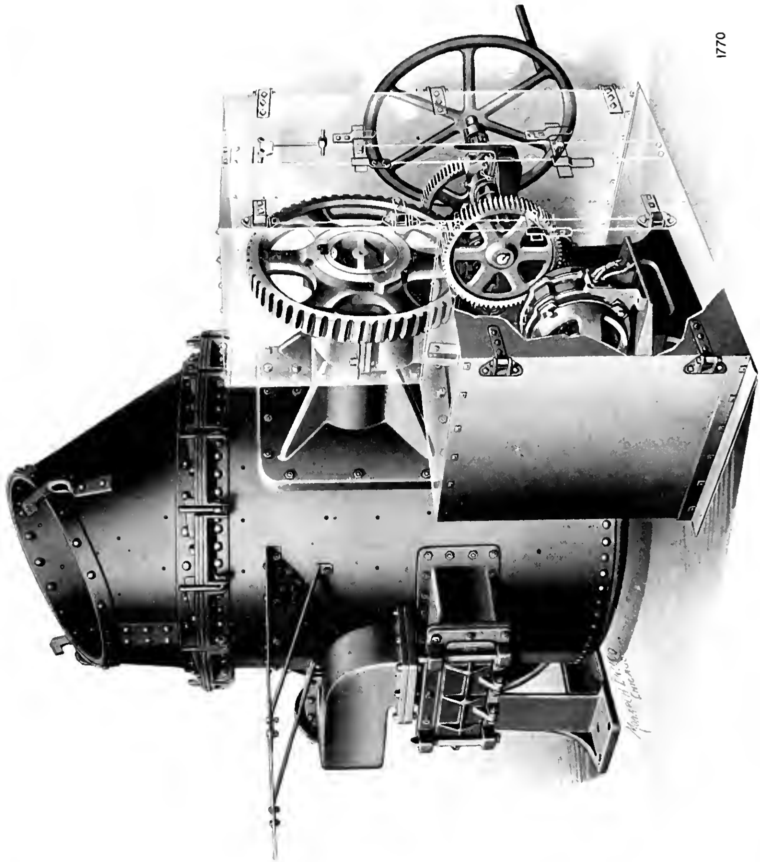
1903—SIDE DUMP CHARGING MACHINE IN DUMPING POSITION

CONVERTER PRACTICE

The lining of a converter is an important thing and before each day of blowing, it requires patching. In order that the blows be successful the lining must be kept within certain limits. The proper shape of lining is shown very well on page 23. This sketch also shows the proper position of tuyeres in converter.

The first thing done in the morning is to patch up with garnister the holes caused by blowing of previous day. Any slag that adheres to vessel is knocked out and tuyeres inspected to see that they are in proper shape. The importance of all these points must be impressed upon the man doing labor around converter. If the vessel is badly cut, it may be necessary to remove the top, cool down vessel, put in form and ram up new lining. Don't forget that lining in a converter is as important, if not more so, than the calculation of cupola charge.

The converter operator finds out the tonnage desired by the foreman and plans his day accordingly. He informs the cupola tender and charging-room foreman when blast is to be applied and usually works this so that there shall be no overtime, if possible.



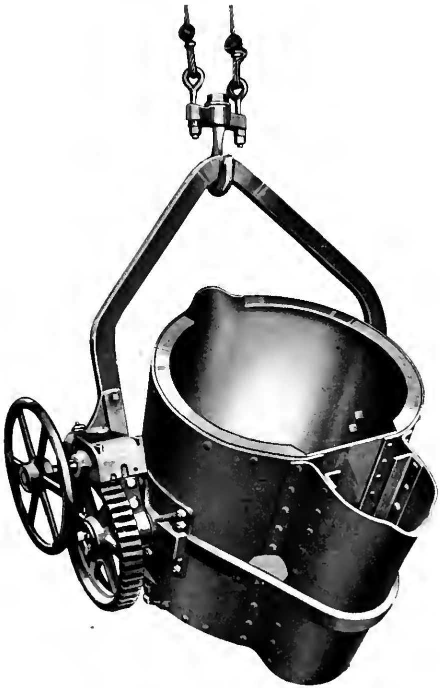
THE WHITING CONVERTER, CAPACITY TWO TONS

If there has been any new patching done to converter, same must be dried out by wood fire. The converter has to be preheated and at our foundry this is done by using crude oil as a fuel, after preliminary heating by wood fire. We figure that it takes from two to two and a half hours to raise temperature of converter up to required point of 2800° Fahr.

If we figure that it will take about forty-five minutes to produce enough iron for first blow, from cupola, then we must start oil blast about one and one half hours before blast is put on the cupola.

The teapot spout ladle that is to be used for first heat, the iron ladles used for cupola metal must also be preheated. Good picture of teapot ladle and iron ladles are shown on pages 64 and 65.

When the molten metal is about ready to charge into converter, the oil is shut off and burner withdrawn from tuyere opening. The vessel is then turned down, allowing all slag which has formed, to come out; this gives operator a chance to see if patching has remained intact. The vessel is then turned back about 15° from the horizontal which gives best position for charging.



TEAPOT SPOUT LADLE COMMONLY USED IN CONVERTER STEEL PLANTS
GEAR COVER REMOVED TO SHOW GEARING

CRANE LADLE WITH ENCLOSED WORM GEARING

CRANE LADLE WITH ENCLOSED PIN SPUR GEARING

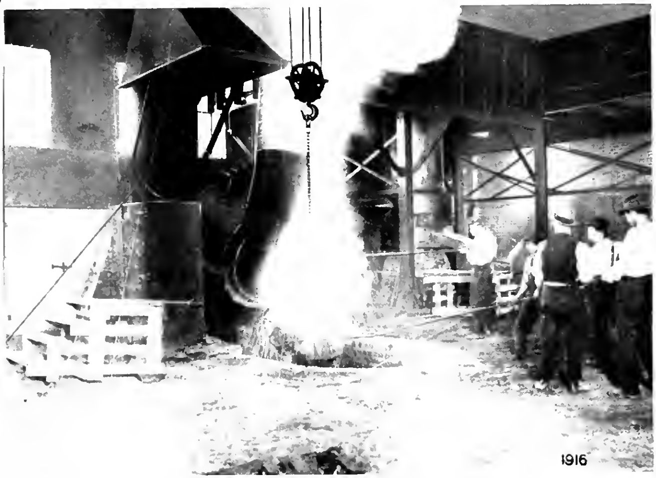
The ladle of iron is now poured into nose of vessel and then vessel is rotated towards vertical. Care must be taken to stop when metal is still well below tuyeres. Now with the aid of a helper at the hand wheel, the operator signals him to bring the vessel toward the vertical gradually, meanwhile watching metal through the tuyere openings, until it comes to a point where it is ready to run into tuyere but can not do so on account of surface tension of molten metal. The best blowing angle is from four to eight. If more than ten is registered by pointer, then there is too much metal in converter and operator should pour out a little by turning vessel back and resetting it as before.

If less than 4°, the metal is short and more should be added before blowing. Having set vessel to proper angle, the wind box is closed and door securely fastened. Blower is started and butterfly valve slowly opened by means of lever on controller platform, until three and one half pounds is indicated on the pressure gauge.

SILICON PERIOD

The blow starts and the first period noted is the silicon period where most of silicon is burned out and where a great amount of heat in blow comes from. This period lasts from three to five minutes.

CHARGING A 2-TON WHITING CONVERTER IN PLANT OF OLIVER CHILLED PLOW CO., SOUTH BEND, IND.



POURING FINISHED STEEL FROM WHITING CONVERTER
Photo by courtesy of Walworth Mfg. Co., Kewanee, Ill.

After this period has terminated, it is advisable to take up a point in order to bring metal up to level of tuyeres. This is because of fact that oxidation of silicon left less in vessel than when blow started.

THE "BOIL" OR MANGANESE PERIOD

The next period is callëd manganese period or the boil. After the flame appears it will be about two minutes before boil occurs, providing that slag is not too viscous or too heavy, which result may be brought about by improper adjustment of mixture. The length of the flame will vary with the temperature and viscosity of the slag.

The flame is very carefully watched during boil period and in case of violent boil, the wind pressure should be cut down and boil checked, never going below one and one half pounds pressure in any case, or the violent swirling of the metal is liable to beat back the low pressure and run into and block tuyeres.

This brings us to the end of the "boil." The flame decreases considerably in size and intensity of heat and operator must be careful not to mistake this for the end of the blow.

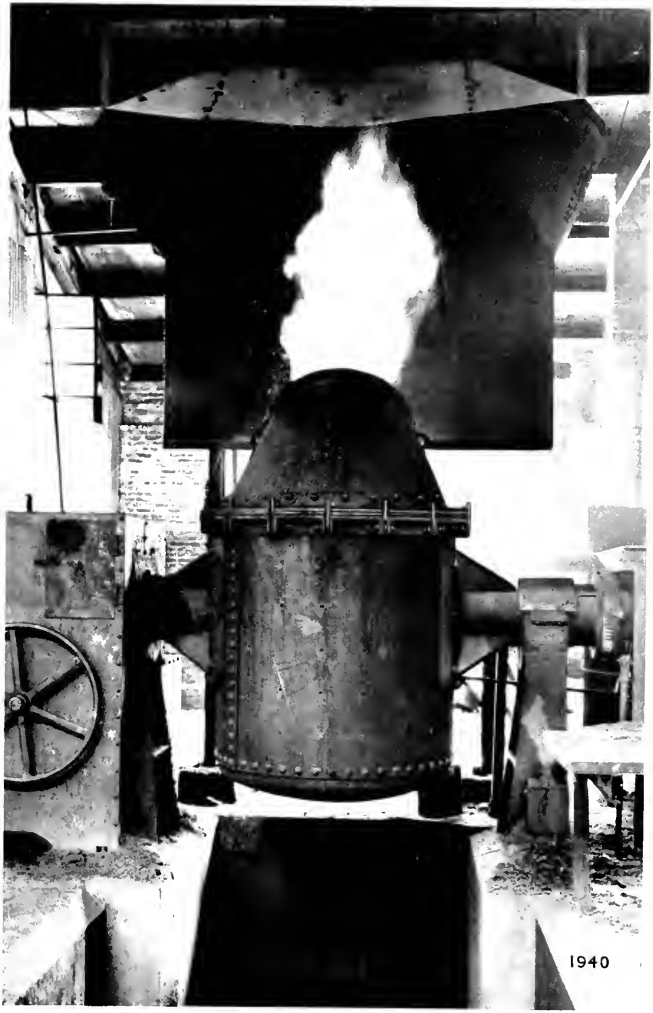
THE CARBON PERIOD

The true carbon flame has not yet appeared, but will do so in a very short time, after which it gradually increases in size and intensity until final drop of flame.

During the carbon period, the flame gradually grows in height and volume until it reaches a point where it seems to be burning with explosive violence. The sparks which earlier in heat fell in great quantity with a scintillating effect, are now scarcely noticeable and fall quietly to the ground. The drop in the flame indicates the end of the blow and the vessel must be turned down immediately and the wind cut off.

The vessel is now tilted forward and wet lumps of ferro silicon and ferro manganese are thrown into bath. These are wet to give explosive effect, allowing them to break through slag. Sufficient cupola metal is added to bring carbon up to desired point. The cupola metal is usually added to ladle. Sometimes it is found necessary to add silicon during heat in order to raise temperature by oxidation.

This completes the blow and metal is poured in teapot ladle, ready for use on steel floor.



WHITING 1 TON CONVERTER IN OPERATION IN OUR OWN FOUNDRY, HARVEY, ILL.
This view was taken during the "carbon period"

Form N

No. C
Car
Be Char
2
3
4
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19
20
TOT

Form N562 (L-5756)

STEEL MELTING AND BLOWING REPORT---W. F. E. Co.

(CUPOLA REPORT)

No. Chg's	Pig Iron	Pig Iron	Pig Iron	Spiegel	Foundry Scrap	Purchased Scrap	Silicon		Coke	Limestone
Car No.	118237	140323	289509							
Bed Charge	150	150	100	6	150	450			550	40
2	"	"	"	"	"	"			125	"
3	"	"	"	"	"	"			"	"
4	"	"	"	"	"	"			"	"
5	"	"	"	"	"	"			"	"
6	"	"	"	"	"	"			"	"
7	"	"	"	"	"	"			"	"
8	100	100	100	6	150	550	5		100	"
9	"	"	"	"	"	"	"		"	"
10	"	"	"	"	"	"	"		"	"
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
TOTAL	1350	1350	1000	60	1500	4800	15		1675	400

	STEEL					CUP. METAL			
Analysis	Sil.	Mang.	Carb.	Phos.	Sulp.	Sil.	Mang.	Phos.	Sulp.
Heat No. 1	.29	.83	.25	.050	.032	1.07	.57	.045	.08
" " 2	.51	.65	.23	"	"				
" " 3	.35	.70	.15	"	"				
" " 4									
" " 5									

METAL REPORT

Metal	Pounds	%
Total Pig	3700	36.65
Total Scrap	6300	62.6
Spiegel	60	.6
Silicon	15	.15
Additions to Ladle		
Ferro Mn.	96	
Ferro Si.	150	
Aluminium	24	
Total Metallic Chg.	10323	100%

HEATS

No. Heats Blown 3

Av. Steel in Ladle per Heat

Av. Metal to Con. per Heat 2800

Av. Cup Chag. per Heat 3441

Heats Lost --

Cause --

Heats Nos. 515 to 517 Inc. For Wk. 11

No Heats Present Lining 468 For Mo. 14

Date Feb. 10, 1920 STEEL

Mixture No. S-14 Cup No. 312

POUNDS

Total Charge 10,323 100%

METAL OUT

Good Castings	6786	65.7 %
Scrap Castings	110	1.1 %
Sprues and Gates	1727	16.7 %
Mill and Drop	125	12 %
		%
Melting Loss	1575	15.3 %

Tons Good Castings 3.4

SCRAP

Total Wt. Castings 689.6

Per Cent of Weight Scrapped 1.6 %

Total Pieces Cast 53

Total Pieces Scrap 2 3.6 %

Foundry Scrap Returned from Shop this Date

Pieces -- Weight --

TIME RECORD

Blast on 2:10 Bottom Dropped 3:40

Time 1 hr. 30 mn. Tons per hour 3.3 tons

Tons Iron Melt per Ton Coke 6.3 tons

REFRACTORIES

Ganister	100
Fire Clay	100
Silicia Grit	--
Loam	100
Brick	--

Signed: SAMPLE

ANALYSIS OF FINISHED CASTINGS

The analysis of each blow and the analysis of each new cupola charge is determined in the chemical laboratory. About the middle of each heat as it is being poured into castings, a test block is poured, 2" x 3" x 4" in size. This is drilled and borings collected for test purposes. The sample must be large enough to allow tests in the following elements: manganese, silicon, phosphorus, carbon, and sulphur.

Care must be taken that no foreign element of any kind is allowed to mix in with borings. These determinations are worked out - the following data sheet shows the result for twenty-five consecutive days.

It will be noticed that whenever vessel was relined that changes in silicon occurred. This shows how closely we come to the same analysis every day. One can easily pick out high carbons and readily check back upon additions made to ladle the day before.

For our grade of work in the Whiting Foundry it is desirable to obtain steel castings as nearly as possible to the following analysis:

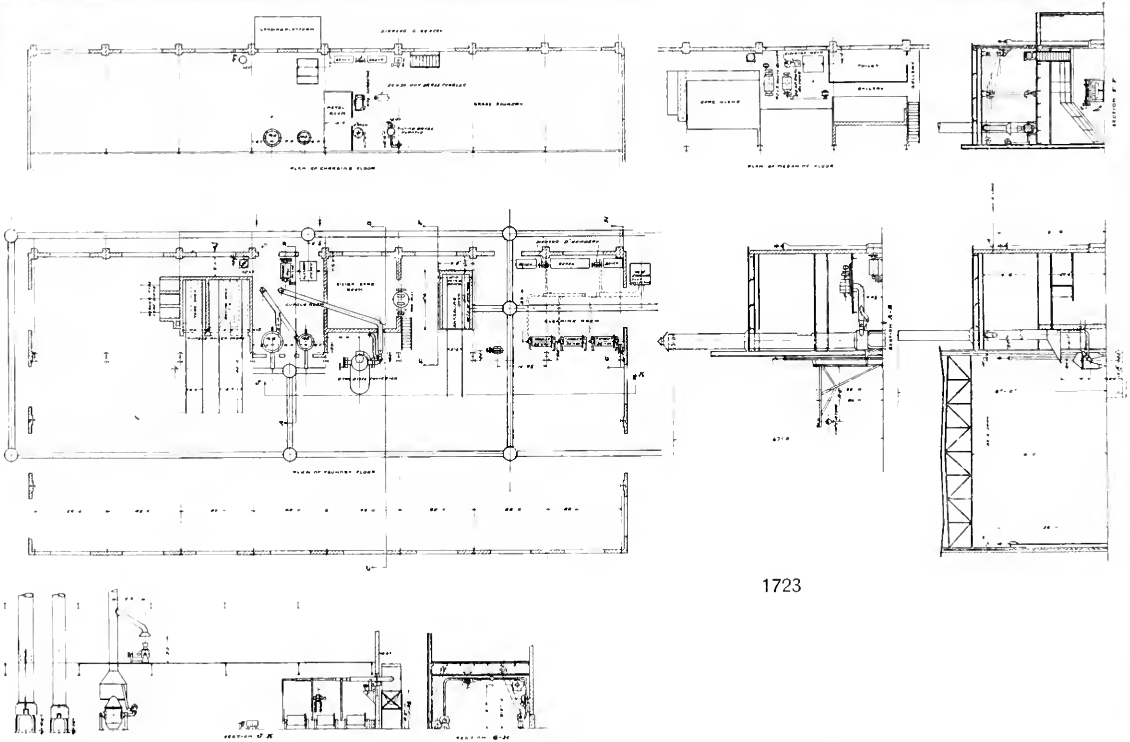
Sil.	Mang.	Sul.	Phos.
.35	.70	.07	.05

ANALYSIS OF CAST STEEL.						
HEAT No.	HEAT No.	C	P	MN	Si	S
509	S-14	23	.048	.73	.35	.098
510	"	23	–	.80	.37	–
511	"	15	–	.74	.34	–
512	"	24	.053	.74	.36	.094
513	"	.23	–	.77	.34	–
514	"	16	–	.73	.32	–
515	"	25	.050	.83	.29	.087
516	"	23	–	.65	.51	–
517	"	16	–	.70	.35	–
518	"	23	.055	.54	.31	.092
519	"	22	–	.67	.38	–
520	"	15	–	.72	.29	–
521	"	23	.047	.73	.32	.098
522	"	24	–	.72	.35	–
523	"	23	–	.73	.33	–
524	"	23	–	.70	.31	–
[illegible]	"	16	–	.72	.35	–

TABLE #3

with a variation of carbon from 20 - 25 to 40 - 50. The last blow is always lower in carbon because cupola bottom has been dropped and there is no metal with which to recarbonize.

Finally, in no better way can we show a model steel foundry, than by the following layout.



1723

Layout of Combination Grey Iron and Steel Foundry, Delaware & Hudson Co., Watervliet, N. Y.

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